Virtual Cement and Concrete Testing Laboratory (VCCTL) Consortium: Questions and *Answers*

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Who will the participants be?

- NIST
  - Building and Fire Research Laboratory
  - Materials Science and Engineering Laboratory
  - Information Technology Laboratory
- Industry
  - CEMEX - Dyckerhoff Zement
  - Holnam - Master Builders
  - Lafarge - W.R. Grace & Co.
- Others (ACI, other companies)

What is the consortium developing?

- A virtual cement and concrete testing laboratory
  - Internet-based and menu driven
  - predicts properties based on detailed microstructure simulations of well-characterized starting materials
  - ultimately tailored to each company's research interests

Properties Predicted by the VCCTL

- *yield stress and viscosity of the fresh material*
- setting time
- volumes of hydration reactants and products as a function of hydration time
- chemical shrinkage
- adiabatic heat signature
- percolation properties
- ITZ microstructure
- diffusivities, thermal, and electrical conductivity
- *elastic properties*
- compressive strength development
- susceptibility to common degradation mechanisms

When and Where?

- When
  - starting in FY 2001 (Jan. 2001 for company participation) and going for at least 3 years (and possibly much longer)
- Where
  - NIST and the participating companies' research centers (national and international)

How will the consortium operate?

- Multiple mechanisms for technology transfer
  - joint research
  - guest researchers at NIST
  - NIST researchers at industrial sites for installation/training/joint research
  - VCCTL web site at NIST and company sites

Why should a virtual laboratory for concrete testing be developed?

- Physical testing of concrete is expensive
  - raw materials
  - storage space (materials and curing)
  - manpower for preparation and testing
  - disposal costs
  - **time** : need to cure for at least 28 days in general before testing

Why should a virtual laboratory for concrete testing be developed?

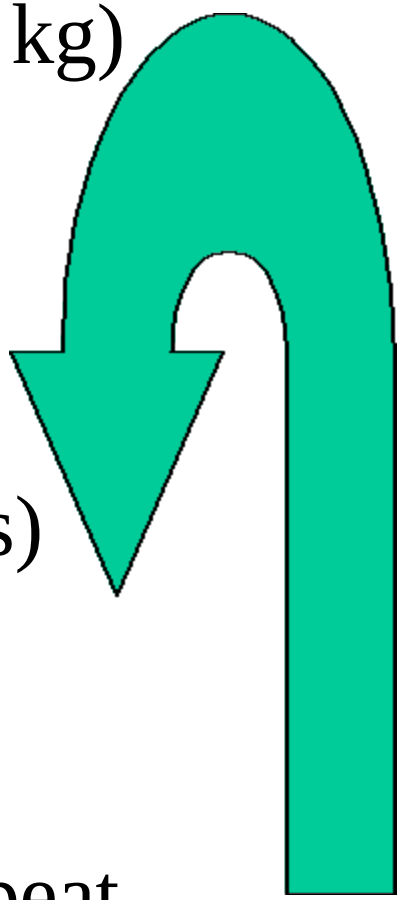
- Research and development currently hindered by:
  - inadequate characterization of starting materials
  - large number of variables
  - long delay between specimen preparation and testing
  - environmental and operator variability
  - cost of research

Why should a virtual laboratory for concrete testing be developed?

- Environmental issues
  - reduced CO_2 emissions
  - "wasting" cement in low w/c ratio concretes
  - introduction of new materials
    - construction industry slow to accept new systems

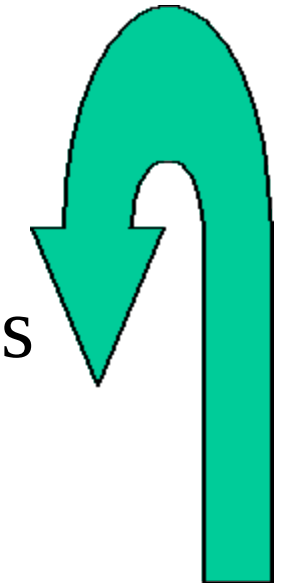
Current testing of concrete

- Obtain raw materials in sufficient quantities for concrete mixtures (hundreds of kg)
- characterize raw materials
- design concrete mixtures
- prepare concrete mixtures
- cure concrete mixtures (>= 28 days)
- test concrete mixtures
- dispose of tested materials
- revise mixtures proportions and repeat



Virtual Testing of Concrete

- Obtain raw materials in sufficient quantity for characterization and making cement paste samples (hundreds of grams)
- **characterize raw materials**
- design mixtures
- simulate microstructure development and/or prepare cement paste specimens
- evaluate properties
- revise mixtures and repeat



Current vs. Virtual Testing

- Current testing
  - physical based
  - manpower intensive
  - materials intensive
  - weeks/months
  - high disposal costs
- Virtual testing
  - computer based
  - computation intensive
  - small material needs
  - days
  - low disposal costs

Other industries (pharmaceuticals, etc.) have successfully gone this route. Is now the time for the cement & concrete industry to be proactive and follow suit??

Typical Costs for Concrete Testing ($300/batch)

Batches/yr	Yearly Cost
1000	$300 K
2000	$600 K
5000	**$1.5 Million**

Startup Costs for Virtual Lab

- PC system with VCCTL installed
  - Pentium III 600 MHz, 512 Mbyte RAM
    - $2500
- Participation in NIST/industry VCCTL
  - $40 K/yr
- **Industry researcher to work with the VCCTL consortium**

Why should NIST coordinate this activity?

- "Best in the World" (#1) in the computational materials science of concrete
- strong synergism between experimental and modeling research programs
- past experience in developing successful Web-based applications
- one of our mandates is to assist industry
  - (dozens of NIST/industry consortia exist)
- active in standards and international organizations (ASTM, ACI, RILEM, ISO)

Why should NIST coordinate this activity?

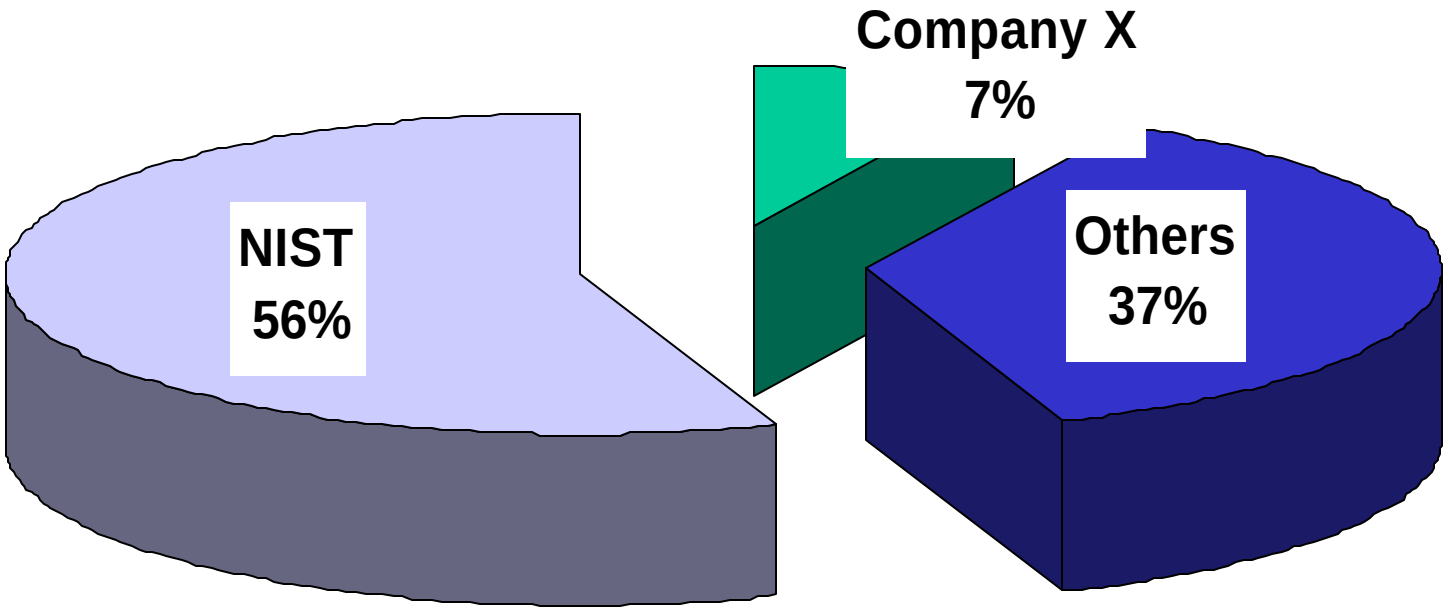
- Objectivity (neutral party as coordinator)
- State-of-the-art equipment for experiments and computations (see handout)
- Human resources (Experts in):
  - cement hydration and microstructure
  - rheology
  - transport and mechanical properties
  - computer modeling
  - particle and microstructure characterization
  - visualization
  - WWW development

Benefits for Consortium Participation

- VCCTL onsite installation and training (onsite or at NIST)
- source code for the VCCTL
- access to extensive NIST facilities and personnel for joint research
- consultation on adapting VCCTL to company's interest & needs
- **participation in a focused project with a clear-cut objective that is directed by the interests and needs of the industry**

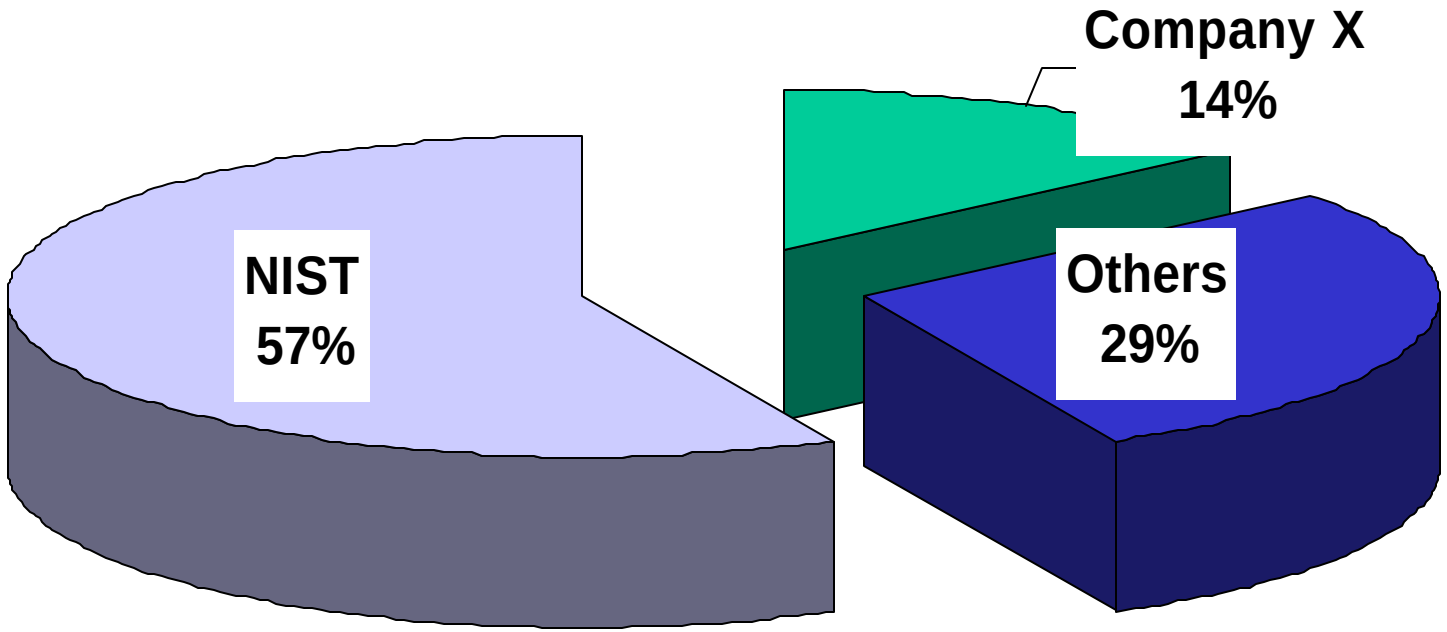
Leveraging of Funds (Best Case)

6 industrial participants; full NIST participation
Total funding: $540 K; leveraging 13.5:1



Leveraging of Funds (Worst Case)

3 industrial participants; partial NIST participation
Total funding: $280 K; leveraging 7:1



Possible Initial Consortium Topics

- Sulfate additions
- Influence of alkalis
- Strength and rheological property predictions for blended cement concretes
- Slag/kaolin additions to CEMHYD3D
- Influence of chemical admixtures
- Controlled PSD to optimize rheological and early-age properties of cement-based materials (cements blended with inert fillers)

Where do we go from here?

- Obtain commitments in writing from industry participants
- Prioritize and detail research topics
- Develop and obtain approval for a **memorandum of understanding (MOU)** outlining consortium objectives, resources, and financial and intellectual exchange

More Questions

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